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DEVELOPING THE DATA FRAMEWORK FOR EFFECTIVE TIMBER MANAGEMENT

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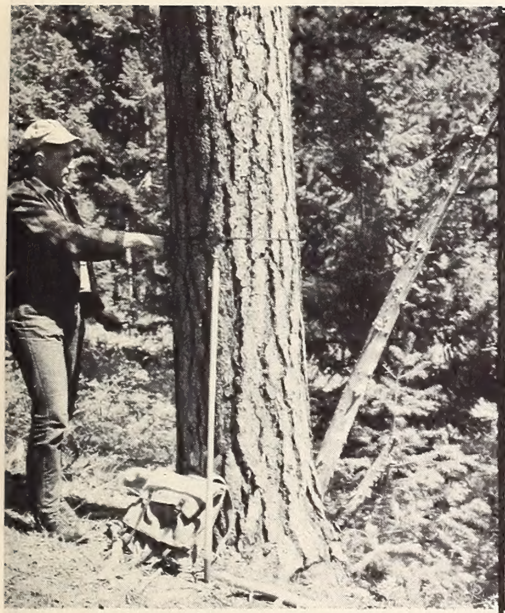
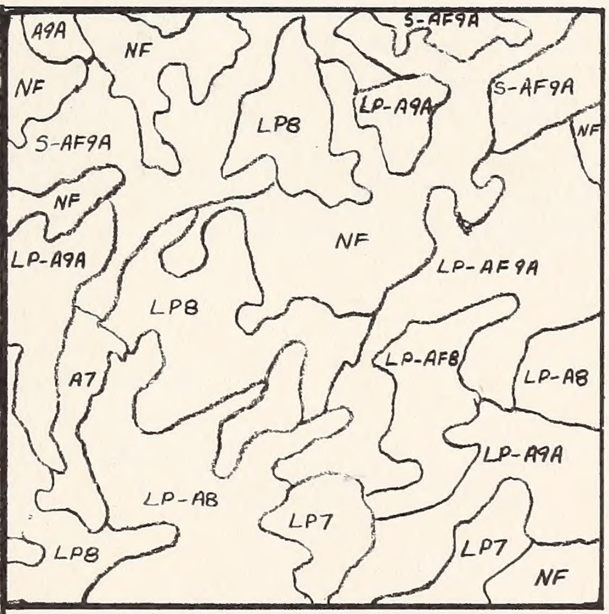
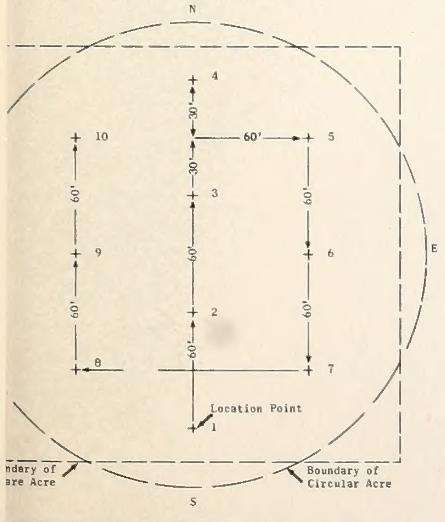




AYOUT OF 10-POINT MULTIPLE-PLOT GRID



INTERMOUNTAIN FOREST & RANGE
EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
OGDEN, UTAH
REED W. BAILEY, Director

MISCELLANEOUS PUBLICATION 25

1962

FOREWORD

The forest survey operation in the Mountain States is almost three decades old. Since 1933 the branch of research of the Forest Service has been cooperating with forest administrators in the collection of inventory, growth, and drain information required for the development of regional and national forestry programs and the administration of the forest on the local level.

Researchers have been involved in the survey for a particular reason. The forest of this country is a huge and highly variable resource. There is a need to coordinate inventory activities to assure the collection of data that are additive for the purpose of making regional and national evaluations of the forest situation. There is a need also for a research effort to produce more useful data and to develop improved inventory techniques.

As a result of this cooperation between researchers and forest administrators, there has been a steady evolution of survey methodology. This report is another effort in that direction. It presents some new thoughts on the subject of the data structure required for effective planning and timber administration. Moreover, it suggests a fundamentally different approach to the task of collecting this information. Inasmuch as the data we have to work with are the foundation of forest management, this provocative discussion will be of interest to most foresters in the Mountain States.

REED W. BAILEY, Director
Intermountain Forest and Range
Experiment Station

MISCELLANEOUS PUBLICATION 25 1962

DEVELOPING THE DATA FRAMEWORK FOR EFFECTIVE TIMBER MANAGEMENT

Division of Forest Economics Research
Division of Forest Management Research

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INTRODUCTION

The forest management job in the Mountain States has evolved over the years from a simple effort primarily concerned with protection to an increasingly sophisticated task of converting a wild forest to a higher rate of productivity. As might be expected, the data needs of forestry have evolved correspondingly. At one time the only concern of timber survey crews was to determine the amount and location of merchantable timber. Timber volumes have continued to be the dominant consideration in inventory work over the years. However, information that indicates the condition, productivity, and management opportunity in commercial stands is rapidly assuming an equal place with volume estimates in forestry statistics.

This increasing concern about the care and treatment of young stands is forcing a complete recasting of survey procedures. The stand classes used to stratify the forest in the past have only limited value in describing management needs and priorities. We have grouped stands into broad size classes, i.e., sawtimber, poles, and seedling-sapling, that are useful for estimating volume but are inadequate for management. For size to be significant for management purposes, it must be related to such factors as age, vigor, and stocking.

For the same reason, the broad stocking classes used in the past are inadequate. A stand of well-stocked poles may have its trees nicely distributed and require no treatment at present; it may be overcrowded and in need of thinning; or it may be so badly overcrowded as to have little or no growth potential. Similarly, a stand classed as poorly stocked may be a more or less homogeneous situation of poor stocking, or it may consist of overdense thickets in need of thinning intermixed with openings that may have to be planted.

The dual problem of timber data and procedures for gathering data has not yet been solved. Much time and effort have been directed toward getting better inventories, but it is safe to say that from a timber management standpoint, the statistical picture of the forest is still a confusing panorama of trees. This is partly because land management units on public properties are large and have a multitude of stands with widely differing characteristics and potentialities. On such land units management planning becomes a giant and difficult jigsaw puzzle. The bigger cause for the present difficulty, however, is that forestry data collected thus far have not been adequately descriptive. They have failed to completely provide the information basic for answering such questions about silvicultural needs as: What? Where? and How much?

The purpose of this report, therefore, is to consider the problem of inventory procedures and statistics from the standpoint of developing a data structure for management controls in addition to determining the area and volume of timber in different categories.

THE PROBLEM OF APPROACH

Forest inventories should serve two functions for the timber planner. They should tell him the amount, character, condition, and location of the merchantable stands as a guide to utilization and the cultural programs associated with utilization. They should tell him the amount, character, condition, and location of the young timber as a basis for planning sustained yield programs. Actually, both are but aspects of a single management job because utilization and forestry efforts must be correlated if production of timber is to be sustained at a high level.

Inasmuch as the typical public land manager faces a problem that is too complex to be comprehended and resolved by observation alone, he must depend upon systematically collected data to describe his land resource. To be descriptive and meaningful, inventory data must provide the basis for answering the following questions:

- How much and what kind of merchantable timber is there? What is the lasting quality of the merchantable timber? That is, to what extent can the existing merchantable reserve be spread over the years in developing a sustained yield program?
- What kind of regeneration problems will these merchantable stands present when they are cut?
- Where are the merchantable stands of different characteristics located?
- What are the size, age, vigor, and potentialities of the principal trees in the young stands as they relate to management needs and opportunities? How are the principal trees in the young stands distributed and how are the secondary trees distributed in relation to them?
- Where are the young stands of different characteristics located?

AN INVENTORY THAT ANSWERS THESE QUESTIONS WILL HAVE TO DO THREE THINGS: FIRST, IT WILL HAVE TO DELINEATE RECOGNIZABLE STANDS, THAT IS, STANDS WHEREIN THE TREES HAVE COMMON CHARACTERISTICS. SECOND, IT WILL HAVE TO DESCRIBE THE TREES WITHIN EACH STAND, NOT ONLY AS TO SIZE AND SHAPE, BUT ALSO AS TO VIGOR AND POTENTIALITY. THIRD, IT WILL HAVE TO PRESENT A PICTURE OF THE TREE DISTRIBUTION PATTERN WITHIN EACH STAND.

Past inventory procedures appear lacking

Past inventories have had one serious deficiency. They did not describe the forest in terms that indicated management needs. This weakness had its roots in the fact that timber surveying was not wedded to timber management. It stands to reason that the timber surveyor cannot be sure what to measure until the timber manager tells him what is significant.

One surveying technique used was a mapping procedure. Stands were delineated and their volumes estimated directly. This procedure was largely abandoned primarily because it is impossible to decribe mathematically the errors involved in volume estimation by such a procedure.

The mapping procedure was replaced by sampling surveys that are easier, quicker, and statistically acceptable ways of determining total volumes. However, no timber surveyor has used these samples to full advantage for collecting management information. In addition, the samples usually are so widely spaced that they give little clue as to where stands of different characteristics are located.

Several attempts have been tried to combine mapping with sampling but these too have failed to provide the data needed for management. This is not because a compromise approach is undesirable. The solution does appear to lie in some combination of the two techniques. However, the point that seems to have been missed in the past is that the purpose of timber surveys is to do more than classify the forest into broad stand categories. They should also describe each stand in a way that indicates its potentialities and what can and should be done to capitalize on the management opportunities it presents. That is to say, categorizing will be of little value unless the categories provide an indication of what needs to be done.

Because of the need for really meaningful categories, development of adequate stand descriptions for any forest presupposes considerable insight into the problems and characteristics of that forest. Such insight normally can be gained only through some sort of reconnaissance that in itself is systematic and complete.

Past compromise procedures have precluded doing a completely discriminating job of stand description because the sample plot and map portions of the survey were either done concurrently or the map classifications were set up without regard to the interpretations that could be made and insight that was possible from the plot data. Before more effective survey procedures can be developed, the capabilities and limitations of the plot and stand delineating phases of surveying must be clearly recognized.

THE SAMPLE PLOT is a convenient tool for objectively studying the forest. Within its boundaries all or any part of the trees can be measured in as complete detail as desired. Moreover, because only a small area is being measured, the relation of the individual trees to each other can be recorded. Accurate measurements thus taken on an adequate sample can provide statistically sound volume estimates for the total property. Moreover, recent experience has shown that plots can be designed that will also provide the basis for developing an effective classification of the forest, and from the detailed description of each plot a precise management prescription can be developed and priorities of action established. A plot can be measured in sufficient detail that it constitutes a statistical description of specific groups of trees, including the relation of the individual trees to each other. From such a record it is possible to derive a sample of silvicultural needs and therefore to estimate in detail the total management effort required for the entire property.

THE STAND MAP is primarily a means for localizing data. However, for the map to be useful as a management tool, the classification used must be unusually discriminating. In most instances, it probably is impossible to develop such classifications without first objectively studying the forest with a sample plot survey.

A two-stage approach seems best

Studies at Intermountain Station suggest that the solution to the critical problem of gathering timber inventory data lies in a combination approach but requires separation in time of the plot taking and the mapping functions. We are inclined to believe the most economical way to meet these objectives is to use a two-stage approach such as is discussed in the following pages.

The first stage should be a plot survey that will give the general picture of the forest, including the volume of wood present. It should also provide three other things:

- The data needed for calculating cutting budgets.
- The sort of precise sample measurements required for estimating the nature and cost of necessary management and for determining priorities of action.
- A basis for developing a discriminating classification of stands in the second-stage survey — a classification that is custom-fitted to the situation in the locality being inventoried.

With this type of background, the second-stage survey becomes a means of locating and classifying stands in terms that reflect the management situation, thus providing the basis for direct action. Management and utilization needs can be geographically located with maps. Having the overall appraisal made possible by the first-stage survey, the manager can make his second-stage survey as complete as his situation or finances require. That is, he can produce a full-scale map that locates and classifies all stands, or he can concentrate his efforts on a particular class of stands or in specific compartments and ignore the rest.

THE FIRST-STAGE SURVEY

To paraphrase what was said on the preceding pages, a first-stage survey may be considered to have fulfilled its purpose if it provides an adequate basis for answering these four questions:

1. How much wood do we have ?

2. What trend of cut of different species and sizes of trees is compatible with the yield objectives set for the forest?

3. What sequence of timber cultural measures will be necessary if we are to realize long range yield objectives?

4. What stand classifications will best facilitate the translation of utilization and management programs into on-the-ground action?

The first of these questions is not difficult to answer, but the others are. They are especially difficult in this Region because the natural unmanaged stands that predominate here are extremely complex. Over the centuries nature has built up a forest that structurally ranges from very open to seriously stagnated. Trees in a stand may be fairly uniform or may be a hodgepodge of ages and sizes. Species composition "covers the waterfront" between pure stands and heterogeneous mixtures. And on top of this the several species in a single stand may differ substantially in ecologic adaptability and marketability. This complex is further confused by the influence of a number of forest insects, diseases, and parasites with their individual species preferences. Finally, this forest is superimposed on a topography with a wide elevational range and a broad span of site quality in a disorganized patchwork of stands and stand conditions varying in size from those so small as to be insignificant to those too large to be harvested in a short period.

The variation arising from the interplay of all these factors places a heavy strain on the data structure and makes a discriminating and discerning inventory necessary.

What should a first-stage survey tell us?

To answer the four questions listed above, seven types of measurements seem necessary; those required to determine:

1. CAPACITY OF THE LAND TO PRODUCE

This is an evaluation of site that we attempt to determine from measurements of representative trees or some other criterion.

2. STRUCTURE OF THE FOREST

This is a task of classifying stands to determine how well the pattern of the forest conforms to the sustained yield objective, and where the shortages and overages are.

3. VOLUME

This traditional inventory estimate requires measurement of the diameter, height, form, and defect of all sample trees above the minimum sizes.

4. GROWTH

This likewise is a traditional estimate based on diameter changes in sample trees.[1]

5. INFLUENCE OF DESTRUCTIVE FACTORS

This requires recording the presence of and damage by insects, diseases, and other destructive agents.

6. IDENTIFICATION AND DESCRIPTION OF CROP TREES[2]

Here we are selecting the trees in the sampled stands around which management should be planned. Relative size, quality, growth potential, and the relation of trees to each other all help in selecting crop trees.

7. DESCRIPTION AND INFLUENCE OF EXCESS TREES

The purpose here is to consider the influence of the noncrop trees upon the crop trees. This requires not only describing the excess trees but considering the competitive influence of each excess tree.

Items 1 to 5 are standard products of traditional timber survey procedures. Items 6 and 7 are not. They represent new data introduced for describing the cultural opportunities and problems in the forest. The reason management decisions tend to require different measurements than volume estimates is that the manager must not only take into account the characteristics of the individual tree, he must also consider the microgeographical relationship of trees to each other. As already pointed out, the arrangement of trees within any stand makes all the difference in the world as to what needs to be done in that stand. This fact has forced inventory specialists to devise ways for showing how the trees in a stand are distributed, as well as what they are like.

How can such information be collected?

The microgeographical factor in management prescription has directed attention away from single plot techniques—such as the 1/5-acre plot. Designers of surveys are finding the answers they seek by using a larger sample—usually an acre, and measuring the variation within this sample area with clusters of 10 to 20 small plots. They have learned that with a series of small plots they can measure the variation within the stand and describe the relationship of trees to each other. Because of the wide variation within stands they are also finding that the volume on an acre can be estimated more accurately from measurements made on small plots than from measurements made on a single large plot.

The individual tiny plot has a special virtue that should not be overlooked. Because the area being considered at any one time is small, it is easy to comprehend tree relationships. It is possible to identify with some accuracy the trees that should be featured in management and describe their relationship to the other trees.

A procedure developed by the Intermountain Forest and Range Experiment Station for collecting both inventory and management data has given the information required for silvicultural prescriptions. While this system is only one of many being studied, it illustrates how a first-stage survey might be conducted.

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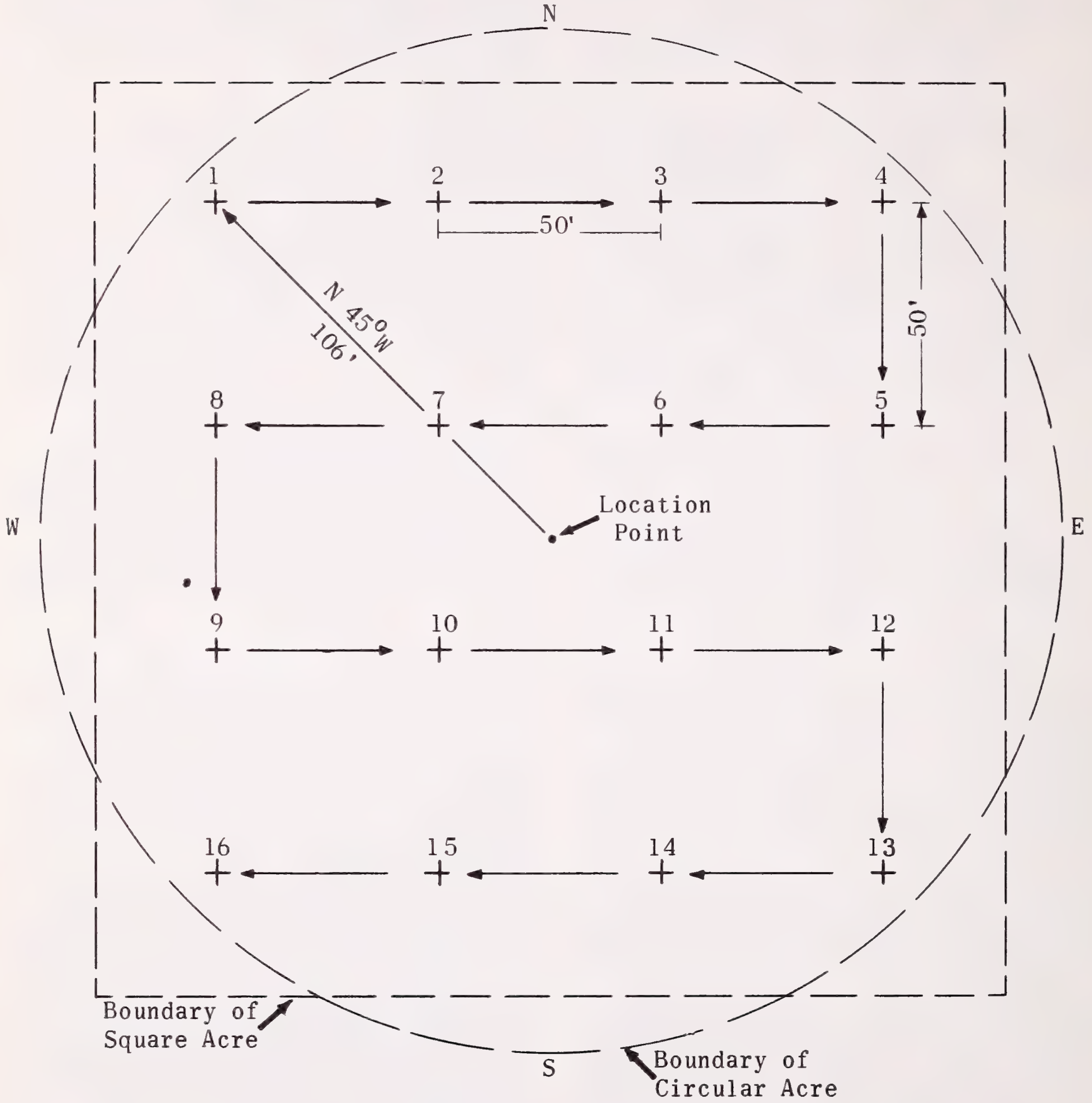
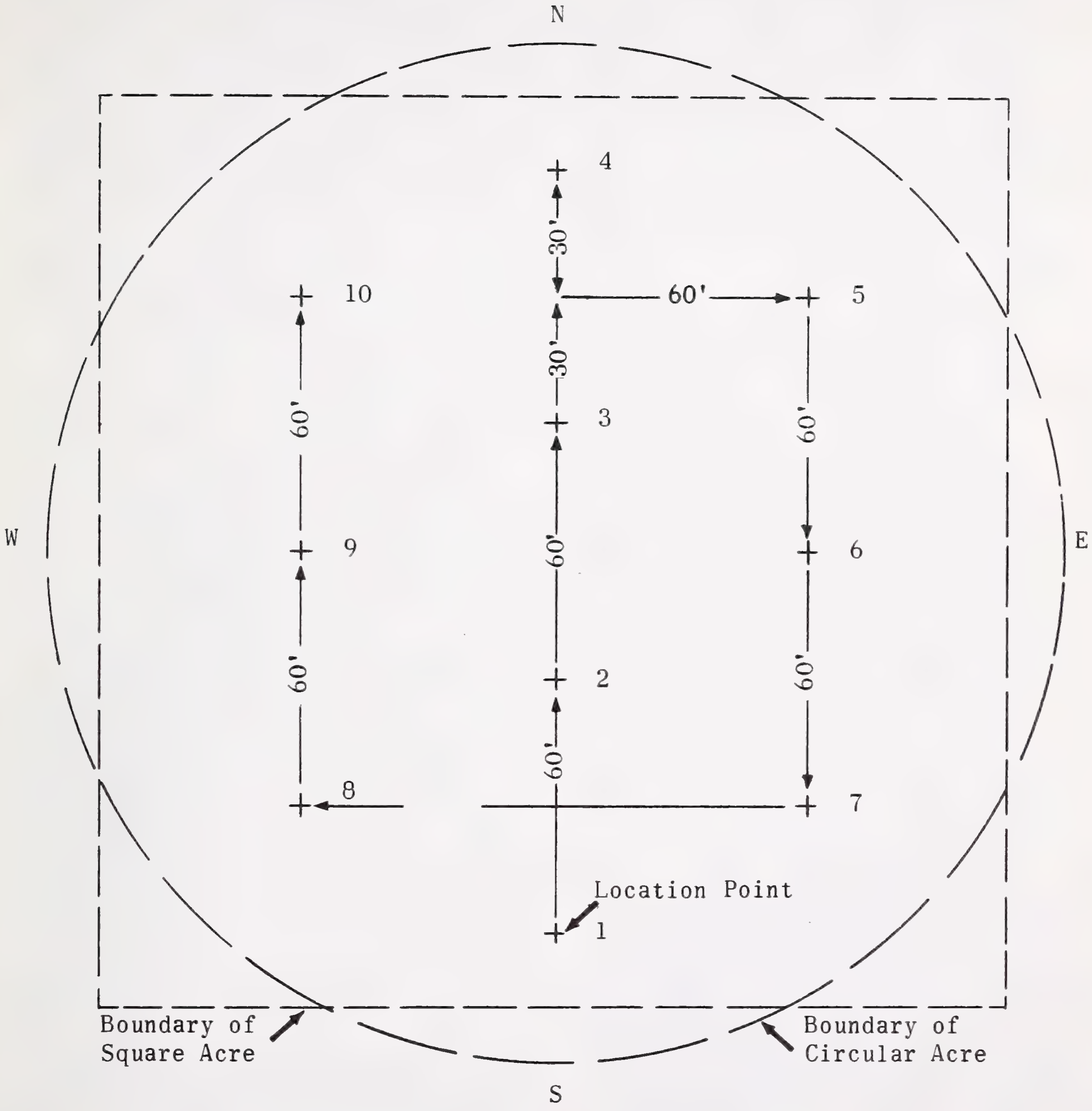
[1] Growth measurements are probably overrated. There is little correlation between general growth estimates, which are related to all trees in the stand, and what could and should be done in an unmanaged forest. The latter is better reflected in the growth of the potential crop trees.

[2] The term "crop trees" as used in this discussion means the trees that will be currently featured in management. In stands to be thinned, "crop trees" is synonymous with "leave trees" in contrast to those to be removed. Many "crop trees" in young stands will, of course, die or be removed before these stands reach maturity.

LAYOUT OF 16-POINT MULTIPLE-PLOT GRID



LAYOUT OF 10-POINT MULTIPLE-PLOT GRID



The principal features of the Intermountain system and the main data collected by it are described briefly in the following paragraphs:

- It is an acre-sampling procedure. A grid of plots is so arranged as to sample the acre in which it lies.
- Different grid patterns may be used. This Station has used a square 16-point grid with a 50-foot spacing between points (fig. 1). It has also used a hexagonal grid of 10 points (fig. 2) with about 60 feet between points.
- Two plots are measured at each point—a fixed area plot and a variable area plot.[3]

  The variable area plot is based on a 75.625 basal area factor; that is, trees are included if their distance from the plot center in feet is no greater than their diameter in inches.

  In the 16-point grid each fixed area plot is 1/256 of an acre in area. All 16 plots add up to 1/16 of an acre. In a 10-point grid each fixed plot is 1/250 of an acre. All 10 plots add up to 1/25 of an acre.
- Sawtimber volume is determined by tallying all sawtimber-size trees falling on the variable plots—that is within range of the 75.625 factor prism at each point. Poletimber volume is determined by tallying all pole-size trees falling within each fixed plot.
- If a tree (or in some instances two trees) growing on the fixed plot is one that would be featured in the management of the stand, this tree (or trees) is classified as a crop tree and described in detail as to size, shape, vigor, etc.
- All of the other trees on the fixed plots are described in lesser detail but sufficiently to indicate their impact upon the crop trees.
- If no trees occur on a plot, cover class, and other secondary information are recorded.

Details of the survey technique itself are explained in field manuals.[4] Most foresters will want to run some plot grids themselves and look at the data thus derived and judge how well they describe each acre surveyed. No matter what grid is used, the purpose of the management measurements on the plot grids is to attempt a somewhat mechanical duplication of the judgments made by a forester when he is deciding what to do with a stand. The procedure is designed to:

- Select and separate out the trees that should currently be featured in management of the acre and to describe these trees in such a way that their potentialities for management and growth can be determined.
- Describe the rest of the trees in terms of their competitive effect upon the "crop" trees and to provide the basis for estimating what and how much should be done to these competing trees.

Using multiple-plot data for management

Volumes are estimated by drawing a composite picture of the individual strata. For example, the volume in pole stands of a particular type in a region is determined by averaging all of the volume samples in that particular stratum and multiplying by the appropriate area "blowup" factor.

However, as indicated earlier, stratum averages of volume tell us practically nothing about management needs, first of all because the stratification used in volume estimating has so little management significance. Second, and more important, is the fact that the variation within each individual stand describes the management job and influences priorities of action. The process of averaging for broad strata obscures variation and therefore provides virtually no indication of management need and priority. For determining the significance of individual samples in terms of amount of work and cost they represent, *these samples must either be grouped in a number of highly refined categories or analyzed individually* to determine two things:

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[3] The variable area plot is generally recognized as the most efficient means for estimating volume. The fixed plot has been incorporated in the procedure described here because it seems to offer certain advantages for management description *which is a substantially different problem than volume estimation.* Perhaps the most important advantage is that with the fixed plot it is particularly easy for the forester to visualize the tree relationships he is measuring.

[4] U. S. Forest Service. 1962. Intermountain Station Integrated Forest Management—Inventory Survey (Field Handbook). Intermountain Forest and Range Experiment Station. 62 pp., illus.

This manual describes the 10-point system.

1. The potentialities of each stand situation sampled. For example, how long will it take a 50-year-old sapling stand to produce merchantable products?

2. Management needs and opportunities in each stand situation sampled. These data provide a basis for estimating how much thinning and pruning and other cultural work may be desirable on the acre, based on the management criteria being followed.

Such data make it possible to develop a general program of yield expectancies (allowable cut) that is directly related to the condition and potentialities of the stands in that area and the treatment planned. These data also provide the basis for describing the total management job on the area being sampled by type of activity, man-hours, and cost. Since the estimates of allowable-cut and management needs thus derived would be from the same data, they would have a compatibility that has been only coincidental in the past.

THE SECOND-STAGE SURVEY

A land manager who has made a first-stage survey of the type described has essentially completed his inventory. He has provided himself with statistically reliable estimates of volume and of cultural needs.[5] In addition, he has a basis for establishing priorities of action. He is therefore in a position to decide how he wants to utilize the forest, and what sort of cultural program he would undertake in the next few years. But he is still left "hanging." He has no way of knowing from his first-stage data where the stands are located that he would turn his efforts to, and he has no way of relating his programs to specific stands on the ground.

He can try to recall where he saw certain kinds of stands, or examine aerial photos and imagine what he cannot see. Or, he can send someone out looking. However, none of these alternatives takes the place of some sort of systematic record, such as a stand map, that shows where the stands of different characteristics are located. Furthermore, it is doubtful that in the long run any of these other alternatives are any cheaper than stand mapping.

Here we should reemphasize the important difference between the plot and mapping functions of survey:

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[5] The procedure for establishing the statistical reliability of estimates of either timber volume or of amount of cultural work needed has been omitted since this discussion is concerned only with the broader aspects of survey design and philosophy.

THE PLOT GRID IS ESSENTIALLY A LOW-COST TOOL FOR GATHERING BIAS-FREE DATA THAT MAY BE STUDIED TO DECIDE WHAT IS SIGNIFICANT.

THE STAND MAP IS ESSENTIALLY A DEVICE FOR DELINEATING AND CLASSIFYING AND CANNOT BE USED EFFECTIVELY UNLESS WE KNOW IN ADVANCE WHAT IS SIGNIFICANT.

A lot of timber mapping done in the past has suffered because the significance of the classifications was not adequately weighed. Forest areas were classified at the time the plots were taken using preconceived and oversimplified systems that did not adequately define stands in the particular locality. As a consequence, the maps when completed had very limited utility because the factors considered in classifying the stands were not always pertinent to managing the forest concerned.

The factors to be considered are the same as in first-stage survey

If we look at the mapping function primarily as a means of locating the stands in which management action is to be taken, it is obviously necessary to classify each stand in terms that adequately describe the action needed.

Management decisions derived from the first-stage survey will have been based on the measurements of number, size, and vigor of "crop" trees and the number, size, and competitive influence of the other trees. In the second-stage survey, stands should be catalogued in the same terms. For example, in those stands where thinning is possible the fieldman must do more than make the standard classification by type, stand-size, etc. In addition, he must judge:

- The number, size, and vigor of crop trees.
- The number, size, and influence of competitive trees.
- The extent and intensity of attack and damage by destructive agents.

From these he can stratify the stands according to a scale of management needs and opportunities.

If the program analysis from the first-stage survey indicates the desirability of commercial thinning, the stands of larger trees might very well be classified according to some criterion that indicates the nature of the commercial thinning opportunity. All immature stands probably should be classified into yield potential groups derived from the analysis of first-stage survey data. Deforested areas might be classified according to plantability and so on.

We should emphasize here that the stand description of the second-stage survey is primarily a subjective process in contrast to the statistical orientation of the first stage. In other words, because it would be impractical to sample any stand heavily enough to describe it with measurements alone, stand mapping is essentially a matter of looking at a stand and deciding what it is.

This does not mean that plots are not necessary for the purpose of aiding judgment. For example, George F. Weyermann and J. Robert Jansson of the Forest Service have found it desirable to run a string of 5 or 10 fixed-size plots through each stand to get a better idea of composition than could be obtained from observation alone.

The mapping job

Field delineation, examination, and description of individual stands are expensive. Consequently, mapping probably should not be undertaken until the forestry situation in the area being surveyed is understood and the decision to begin managing has been made. Even then it may be desirable to map only a portion of the forest.

An advantage of the advance insight gained from the first-stage survey is that it gives opportunity for latitude in making the second-stage survey. For example, if limited finances or other circumstances force the manager to confine attention to certain kinds of stands or to certain areas, he would not have to do a total mapping job. To be more specific, if the money available is adequate only to thin in vigorous young stands, the forester would not need to spend time wandering through and classifying sawtimber. All pole-size and smaller stands could be located by using aerial photographs. Once such stands are located, they could be further classified by field examination.

If the manager has the information available to establish area priorities, he may prefer to select certain compartments for management treatment. Then, it would be necessary only to make the second-stage survey for those compartments.

Photos are an important mapping aid

In any event, photos should play an important role in mapping. Differences in forest condition due to tree size and stocking can be delineated on the photos prior to field examination. Also, the most practical way to further delineate most stand conditions in the field is to trace out the differences on the photos as they are recognized on the ground.

The importance of aerial photos in stand delineation and classification can hardly be overstressed. Not only do photos provide the basis for accurate stand delineation, they are an inexpensive way to obtain much of the classification information for timber stands. Of course, full use of photos is predicated on having men well trained in photo techniques. Unfortunately, such men have not always been available, and stand mapping has suffered.

A good record system is vital in stand mapping

Besides the inadequacy of the traditional classifications, another factor limiting the usefulness of stand maps in the past has been lack of an adequate method for organizing the data. If only a limited amount of stand delineation is done, the record keeping can be very simple. It may be necessary only to draw lines delineating the stands on the aerial photos and to record the descriptive information on the backs of the photos. Sooner or later, however, a complete record will be needed for the area on which commercial timber is to be grown. When this stage is reached, the manner in which the data are set up will be all-important. One big drawback of past stand mapping practices has been that map information for large areas has represented a cumbersome and in many respects unusable stack of data. For example, it is one thing to know that a specific number of acres is in a given stand condition, but something else to locate the individual stands that make up the total when that condition must be treated.

All this leads to the conclusion that when stand maps have been prepared for a large area devoted to production of timber products, some flexible system should be installed for maintaining stand records.

Experience gained at this Station indicates that machine bookkeeping integrated with the maps offers a practical solution to the problem of keeping track of data. Recently a stand mapping survey was completed on the North Slope of the Uinta Mountains in Utah. About 400,000 acres of commercial forest in 12,000 stands were mapped, using photos in the manner just described. A preliminary delineation was made on aerial photos; later the stands were further delineated and classified in the field.

In compiling the data an IBM bookkeeping procedure was keyed to the maps. Briefly the steps were these:

- Stand delineations were transferred to a 2-inch-to-the-mile township base map.
- Stands were numbered by compartments on the maps because it was not possible to write all of the pertinent data within the delineated areas.

- The data for each stand were recorded on an IBM card.
- An IBM listing (tabulation) of stands by compartments and township was made to accompany the township maps.

The system offers a high degree of flexibility because stands of any specific combination of characteristics can be located by a simple machine sorting. In addition, the machines can be utilized to list stands by township, compartment, and stand number. Whenever a stand is treated or changed through natural causes, a new card can be made.

FEASIBILITY OF A TWO-STAGE APPROACH

Tight budgets have pretty well restricted inventory programs. This has been one of the factors causing the emphasis on sampling procedures. The Regionwide forest survey has, for example, been able to get by cheaply because it is designed to give accurate estimates for large units and not to provide data for local use. Field cost of such surveys, plus direct supervision, runs from ½ to 1¼ cents an acre. Survey work on the National Forests is more intensive because usable data are required by working circles. A typical cost for field plots on the National Forest is 3 cents an acre. Compilation costs are in addition, of course, and amount to several cents an acre.

By these standards the approach described in the preceding pages is expensive. For example, the cost of two-stage inventories on a working circle containing 500,000 acres of commercial forest in western Montana might be as follows:

STAGE 1 SURVEY

	Cents per acre
Field costs	3
Compilation costs	1
Total	4

STAGE 2 SURVEY

a. Mapping only the highest priority half of the compartments but not carrying the map information beyond the photos.

Field costs (based on total area)	2½
Compilation costs	1
Total	3½

b. Mapping the entire area but not carrying the map information beyond the photos.

Field costs	5
Compilation costs	2
Total	7

c. Mapping the entire area preparing three-color printed maps, and recording the data for each stand on a punch card.

Field costs	5
Compilation costs	6
Total	11

The question naturally arises: Can one justify a cost of 7½ to 15 cents an acre for collecting and compiling the data needed for planning? Flat standards for inventory expenditures should not be established for all places because timber values vary from one part of the Region to another. Nevertheless, three factors must be considered:

The first factor is the great complexity of the wild forest we are attempting to bring under management. There is no need to elaborate here beyond pointing out that natural stands differ greatly in their capacities because of site and vigor variations.[6] The forest manager is therefore forced to consider very carefully the potentialities of each stand he expects to manage. He cannot operate satisfactorily from bland groupings of stands of the saem age or size class or some other category.

Second, because the situation is complex the cost of fumbling will be high. Any attempt to operate from inadequate data will inevitably create its own type of avoidable costs. Time wasted in attempting to actually locate stands needing different kinds of attention, and wrong levels of cut arising from uncertainty as to the potentialities of individual stands could eventually prove to be very expensive.

The third factor is an aspect of the other two. Reviews of the management problem to date indicate that much needs to be done in the forests of this Region. One study in western Montana indicates the backlog of necessary cultural work in that area will amount to more than $20 an acre.[7] After that, of course, there will be a continuing management job. The prospect of being able to do all or part of this large management job with maximum efficiency is pretty slim without the type of data structure described in this report.

In relation to total management costs, inventory costs of 7½ or even 15 cents per acre are cheap. Considering the cost savings possible through efficient operation, inventory costs amounting to several percent of the total management cost appear justified. Architectural and engineering planning generally are expected to represent upward from 5 or 6 percent of total project cost in construction. Design costs in timber management programming include more than inventory expense but that certainly is a big item. We can conclude that it is no more feasible to manage a large forest from "shoestring" planning than it is to construct a skyscraper on that basis.

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[6] S. Blair Hutchison and Arthur L. Roe. "Management for Commercial Timber Production, Clark Fork Unit, Montana." Res. Paper 65.

[7] Ibid.

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